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ENERGY EFFICIENCY OF SHIPS

EQ-CII metric: A holistic solution based on equivalent transport work principle

Submitted by United Arab Emirates and IPTA

SUMMARY

Executive summary: This document introduces the novel concept of the Carbon Intensity Indicator (CII) called EQ-CII which holistically addresses all the existing CII weaknesses (auxiliary, weather, and capacity) by a twist in the Annual Efficiency Ratio (AER) formula given in the interim CII Guidelines, G5. The EQ-CII concept adds equivalent or virtual transport work based on ship mileage for all the fuel losses due to factors beyond control of ships and without deducting any fuel from the formula. The concept does not need change in existing reference lines, due to the use of DWT or GT of ship as capacity.

While fully supporting the ongoing efforts to improve the CII metric via the G5 Guidelines, as a plan B, just by adding two parameters in the IMO DCS data, i.e. average RPM of propeller and mean draft of the ship during a voyage, better CII projections can be achieved based on the EQ-CII concept. This will help during the review of the short-term GHG reduction measure in 2026. This document proposes a two-step approach for smooth implementation of the EQ-CII metric.

The co-sponsors propose to consider this concept as one of the options during the review of the short-term GHG reduction measure, which was originally presented by the Indian Register of Shipping (IRCLASS) at the RINA CII conference held at IMO on 16 and 17 January 2024.

Strategic direction, if applicable: 3

Output: 3.2

Action to be taken: Paragraph 22

Related documents: MEPC 80/17/Add.1 and MEPC 81/6/6

Background

1 Regulations 25.3 and 28.11 of MARPOL Annex VI require a review of the short-term GHG reduction measures to be completed by 1 January 2026, and annex 13 to document MEPC 80/17/Add.1 defines the Review plan. One of the terms of reference is .6 as follows:

> "The review should focus, in particular, on the following elements:
>
> …
> .6 consideration on further amendment to the CII metrics, as set out in the CII Guidelines G1;
> …"

Therefore, this avails further opportunity for industry to improvise the basic CII formula given in the CII Guidelines, G1, which can remove the burden of amending the CII Guidelines, G5, altogether.

Introduction

2 As a stimulus to reduce the carbon intensity of all ships for achieving net zero targeted in the 2023 IMO GHG Strategy, the Committee adopted the basic CII formula or metric described in the CII Guidelines, G1, by resolution MEPC.352(78) on the *2022 Guidelines on operational carbon intensity indicators and the calculation methods (CII Guidelines, G1).* However, due to inherent weaknesses in the basic formula, the Committee introduced new guidelines, i.e. the CII Guidelines, G5, for correction factors (CF) and voyage exclusions (VE). Until now few ship-type wise activities are covered using CFs and still a lot of such demands are being proposed through submissions to the Committee. For example, document MEPC 81/6/6 (Bahamas et al.) shows around 30 documents describing around 13 major weaknesses that are pending.

3 This document details and simplifies weaknesses/challenges with the current CII metrics and proposes a novel holistic EQ-CII metric based on an equivalent transport work calculation methodology. This can better address the issue of CF/VE without any fuel and/or distance deduction. To implement the EQ-CII metric, ships need to submit just two extra parameters along with the IMO DCS, which are verifiable through existing shipboard records.

Basic CII formula challenges in the CII Guidelines, G1

4 The basic CII formula is as follows:

$$CII_{Ship} = {}^{M}/_{W} = \frac{Total\ Fuel * CF}{Tranport\ Work}$$

$$= \frac{(Total\ Fuel = Propulsion\ + other) * Carbon\ Factor}{DWT\ or\ GT\ \text{as}\ Capacity *\ \ GPS\ distance\ for\ Propulsion} = \frac{Gram\ CO2}{tons.Nmiles}$$

5 In the above basic CII formula, propulsion fuel in the numerator designates the ideal condition where the ship is always fully laden (DWT capacity), with zero other fuel consumption as there is no representative distance in denominator and probably facing calm/assisting weather for minimal fuel consumption in propulsion.

> ***Note:*** "Other fuel" means auxiliary or non-propulsive fuel consumptions for activities such as cargo related loading/unloading, cargo tank cleaning, cooling, heating, geared operations, refrigerated containers, ship-to-ship transfer, port stays, port manoeuvring, pilotage, drifting, standby DP activities, anchorage waiting, shore power etc. All these fuel consumptions are indirectly necessary for useful or direct GPS-based transport work.

6 But in actual life, a ship's operational profile got various fuel headings (refer to figure 1) in addition to just one fully laden ideal condition, and the inability of the basic CII formula to accommodate the root causes results in faulty CII ratings when comparing a ship with ideal conditions or comparing two sister ships with varied operational profile.

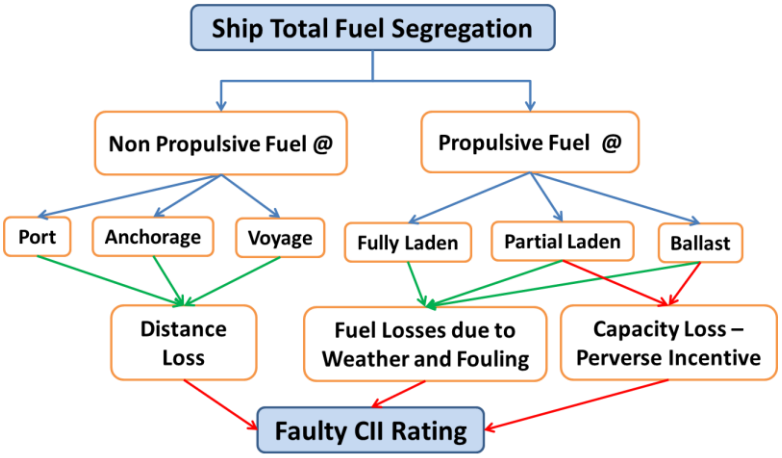

Figure 1: Ship fuel segregation into major types and root cause of the faulty CII values

7 Therefore, the co-sponsors have identified three major challenges with the basic CII formula; which are beyond the ship's control:

.1 other fuel with no GPS distance – varying based on each ship type and size;

.2 weather- and fouling-based increased fuel consumption; and

.3 capacity-based DWT variation in ballast and partial laden voyages.

Challenges arising from the corrected CII formula in the interim CII guidelines, G5

8 In order to deal with some of the challenges, a percentage of other fuel has been deducted in the interim CII guidelines, G5, for a few ship-type specific activities, e.g. ship-to-ship operations of tankers, refrigerated containers, cargo pumps for tankers, cargo cooling-LNG, boiler-cargo heating, etc. Overall, the CII Guidelines, G5, are based on fuel deduction principle, directly or indirectly.

$$\text{G5-AER-CII} = \frac{[(\text{Total Fuel}=\text{Propulsion}+\text{Other})-(\%\ \text{of Other})]*C_F}{\text{DWT Capacity}*(\text{GPS distance for Propulsion})}$$

9 Despite the above corrections, several submissions to the Committee (around 35 documents) request additional ship-type corrections. With the increasing number of CFs, the formula, data gathering and verification will become complicated.

10 The interim formula does not cover anything for weather-based fuel loss except for sailing in ice conditions for ice-classed ships.

11 In addition to this, using a fixed laden DWT capacity as a cargo proxy creates a perverse incentive.

12 The most important drawback of the corrected formula is that the principle of fuel deduction will not encourage ships to use shore power or green fuels for, e.g. auxiliary engines, which are viable and low hanging fruits of decarbonization.

Novel EQ-CII formula – principle of equivalent transport work

13 Contrary to the corrected formula's principle of fuel deduction, in the EQ-CII metric, an additional equivalent or virtual distance is added in the denominator, based on ship mileage, as explained in paragraph 14.

14 To benchmark with ideal ship conditions of the basic CII formula, the EQ-CII formula calculates what equivalent distance a laden ship would have travelled:

.1 with the fuel used for other or non-propulsive activities;

.2 with the fuel used for non-laden (e.g. ballast and partial laden conditions); and

.3 in calm weather with fuel used during non-supportive weather.

For the first two:

$$\text{Equivalent Transport work in NM} = Aggregate\ Laden\ Mileage\ \left(\frac{NM}{ton}\right) of\ ship\ *\ [Nonpropulsive + Nonladen]\ fuel\ in\ tons$$

Here, "laden" means all voyages where the draft is greater than or equal to [75%] of EEDI draft. 14.3 is to compensate for weather losses, while calculating mileage of a ship in laden condition, engine distance is to be used rather than GPS.

$$\text{Aggregate Laden Ship Mileage Nmiles/ton} = \frac{\sum \text{Summation of the Engine Distances in all Laden voyages}}{\sum \text{Summation of the Propulsive Fuel in all Laden Voyages}}$$

To summarize:

$$\text{EQ-CII} = \frac{[\text{Total Fuel} = \{\text{Propulsive (Laden} + \text{Non laden)} + \text{Non Propulsive}\}] * C_F}{\text{DWT Capacity} * (\text{Engine dist. in Laden} + \text{Equivalent Engine Dist. for Non laden \& Non Propulsive Fuel})}$$

Note: For ships with GT as capacity, straight engine distance-based aggregate ship mileage can be taken. Laden and non-laden do not apply.

Additional data in the IMO DCS and verification issues

15 The needs for additional data in the IMO DCS and associated verification issues are assessed as follows:

.1 for non-propulsive fuel correction: no additional data required. GPS mileage of a ship at sea can be considered to calculate equivalent transport or distance;

.2 for laden or capacity correction: mean draft of the ship for a voyage is required to segregate between laden and non-laden voyages in data entries; and

.3 for weather/environmental loss correction: average RPM for a period and pitch of the propeller, along with hours under way (already reported) will allow the calculation of engine distance for a particular period or voyage.

16 Both additional data needs identified in paragraphs 15.2 and 15.3 are easily verifiable from already existing noon reports signed by the master and chief engineer. Mean drafts are publicly available and RPM is recorded via digital tachometers.

17 The engine distance data will help to gauge how much weather losses are happening as a consequence of climate change and draft marks will help to gauge how much useful transport is happening as a market dynamic effect.

Two-step approach

18 Ideally all three generalized gaps, i.e. other fuel, weather and capacity are important. This document proposes to consider this EQ-CII concept in its entirety to amend the CII Guidelines, G1. In case the Committee does not have sufficient time to take a decision on two new data entries important for capacity correction and weather correction, the co-sponsors suggest smooth implementation of the EQ-CII concept, as follows:

.1 Step 1: For immediate and easy improvement without any changes in the IMO DCS, the Committee can go for equivalent transport work only for other/non propulsive fuel where aggregate GPS mileage of ship during port-to-port voyages can be used to calculate equivalent transport work for all other or non-propulsive fuels. This can be introduced via a new section in the CII Guidelines, G5 as an alternative option to all correction factors; and

.2 Step 2: For the short-term GHG reduction measure in 2026, the entire EQ-CII metric along with the two new data points (mean draft of ship and average RPM of propeller) can be introduced on a voluntary basis in the CII Guidelines, G1 as well as the IMO DCS. This will also facilitate to see its impact on the reference lines as well as comparison with other metrics for better decision-making. The initial changes in the IMO DCS are shown in the annex to this document.

Integrity of the reference lines and ease of adoption

19 EQ-CII adoption does not require changes in CII reference lines for three reasons:

.1 In the basic CII formula, except capacity, all other parameters are variable, i.e.: fuel, distance, and carbon factor.

(CII Guidelines, G1 $= \frac{\text{Total Fuel} * \text{Carbon Factor}}{\mathbf{DWT}\ \text{Laden Capactiy} * \mathbf{D_t}\ \text{as GPS distance}}$)

Based on this, only $CII_{ref} = a\ Capacity^{-c}$ segregation formula is derived.

In the EQ-CII metric, the capacity is kept constant same as the DWT or GT of ship.

The EQ-CII normalizes the distances in real operational conditions of ships with respect to standard or ideal conditions, i.e.: laden and calm weather, using mileage in laden condition;

.2 "Normalizes" means the EQ-CII increases the CII value of ships where there might be perverse incentives due to higher ballast voyages or fair weather and reduces the CII values for ships where there is extra auxiliary/other fuel use and weather-loss. EQ-CII makes the CII formula fair for all. This means

it brings the scatter of the CII values close to the C boundary or dense scatter. Thus, having almost negligible effect on reference lines as such. Still, voluntary proposed data submission and further analysis can confirm the deviation in reference lines if any; and

.3 Strategically, the original reference lines were drawn using the 2019 data, and ideally may change every year based on new data. Rather than changing the reference lines, more focus shall be on the CII reduction rates in line with the net zero trajectory.

Encouragement for decarbonization

20 Encouragement for decarbonization is listed as follows:

.1 the mileage at sea will encourage the captain to run the ship efficiently to claim higher equivalent distance for non-propulsive fuel;

.2 compensation for port or non-propulsive fuels will encourage shipowners to opt for greener port facilities such as shore power, green tugs, cargo handling equipment based on green energy. This will bring the port ecosystem into the decarbonization journey;

.3 also, on board ship, owners have cheaper options to replace auxiliary engines with green fuels used for non-propulsive activities;

.4 due to use of laden mileage for non-laden voyages, the capacity-related perverse incentive will not be an option any more;

.5 choice of engine distance will safeguard the ship from uncontrollable weather- or fouling-kind of additional fuel consumption increasing day by day due to climate change effect;

.6 all fuel emissions are kept under the CII formula bracket which will help the Organization to plan for future reduction rates in the CII proportionately across ship types; and

.7 once the formula becomes fair to all ships, the Organization can decide over enforcement levels.

Conclusion

21 The Committee is invited to consider the EQ-CII concept during the review of the short-term GHG reduction measures in 2026, as a holistic solution to amend the CII Guidelines, G1 metric altogether as per paragraphs 13 to 17 or as a parallel alternative to amending the interim CII Guidelines, G5, CII Guidelines, G1, and the IMO DCS based on the two-step approach given in paragraph 18.

Action requested of the Committee

22 The Committee is invited to consider this document and take action as appropriate.

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ANNEX

CHANGES TO THE IMO DCS IN RESOLUTIONS MEPC.348(78) AND MEPC.388(81)

Changes to the *2022 Guidelines for Administration verification of ship fuel oil consumption data and operational carbon intensity* (resolution MEPC.348(78), as amended by resolution MEPC.389(81))

Existing template to submit data

APPENDIX 2

SAMPLE OF THE COLLECTED DATA SUMMARIES

Date and time from (dd/mm/ yyyy; hh:mm UTC)	* Date and time to (dd/mm/ yyyy; hh:mm UTC)	Distance travelled (n.m)	Hours under way (hh:mm)	**exceptional conditions specified in regulation 3.1 of MARPOL Annex VI (Y/N)	**Sailing in ice condition (Y/N)	**STS Operation (Y/N)	Fuel consumption (metric tons)							
							total mass		**mass to be deducted from the total					
									consumed for production of electrical power ($FC_{electrical}$)		consumed by oil-fired boiler for cargo heating/discharge on tankers (FC_{boiler})		consumed by standalone engine driven cargo pumps during discharge operations on tankers (FC_{others})	
							***DO/GO	...	DO/GO	...	DO/GO	...	DO/GO	...
01/01/2023 00:00	01/01/2023 13:20	150	13:20	N	N	N								
01/01/2023 13:20	01/01/2023 24:00	60	10:40	N	Y	N								
02/01/2023 00:00	02/01/2023 24:00	288	24:00	N	N	Y								
03/01/2023 00:00	03/01/2023 24:00	260	24:00	N	N	Y								
.....	.....	.....	.....	.....	.....	.....								
.....	.....	.....	.....	.....	.....	.....								
31/12/2023 00:00	31/12/2023 24:00	290	24:00	N	N	N								
Annual total														

New template for daily data collection

Sr. No.	Voyage No.	Date and Time From	Date and time to	(GPS) Distance Travelled	Hrs Under way (hh:mm)	**Mean Draft**	**Average RPM**	Propulsive or Main Engine Fuel type wise consumption			Non Propulsive or Other Consumer type and Fuel type wise consumption		
											Consumer type-1		
								Type1	Type2	Type...	Type1	Type2	Type...
1	1	31-12-2023, 00:00	01-01-2023, 05:00	49	5	**11.78**	**83**	3.31			0.3		
2	1	31-12-2022, 05:00	01-01-2023, 24:00	197	19	**11.78**	**72**	16.47			1.75		
3	1	02-01-2023, 00:00	02-01-2023, 24:00	250	24	**11.78**	**91**	19.96			2.02		
4	1	03-01-2023, 00:00	04-01-2023,01:00	273	25	**11.78**	**90**	19.83			2.17		

In the above table, **bold font** is only the extra data. The IMO DCS is already gathering non-propulsive (auxiliary, boiler and other) fuel as "Not Under way" as per regulation 27 (collection and reporting of ship fuel oil consumption data) of resolution MEPC.385(81).

Changes to the *2022 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)* (resolution MEPC.346(78) amended by resolution MEPC.388(81))

Total transport work (paragraph 7.11 of the SEEMP Guidelines)

Cargo Ship

$$\text{DWT Capacity} * \sum(\text{Engine dist. in Laden Voyages} + \text{Equivalent Engine Dist. for Non laden \& Non Propulsive Fuel})$$

Cruise Ship

$$\text{No of Passengers} * \sum(\text{Engine dist. in voyages} + \text{Equivalent Engine Dist. for Non Propulsive Fuel})$$

Based on these basic changes in the IMO DCS, other resolutions and guidelines can be amended.

Link for the EQ-CII concept developed by IRCLASS – Reference material: Shared Folder
https://drive.google.com/drive/folders/1WOnUxGc3-0Rymdklqa1TWJAbyWseifZT?usp=sharing